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ABSTRACT

This paper provides principles which can be used to mark mathematics papers in secondary schools. Sections included are: (1) "Drafting the Marking Scheme" (describing 15 general considerations); (2) "Calculations" (listing 16 grading principles on computation papers); (3) "Graphs" (providing four guidelines on graph papers); (4) "Constructions" (presenting the points for which the marks are given); (5) "Actual Marking" (containing some checking instructions); and (6) "Coordinating the Marking" (offering seven procedures for maintaining the consistency of the marking between different teachers). (YP)

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PRINCIPLES OF MARKING MATHEMATICS PAPERS

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INTRODUCTION

This handout provides some principles which can be used to mark mathematics papers in secondary schools. The application of these principles should lead to more objective marking schemes and improved consistency among different markers. The end result is fairer to the student whose effort is rewarded appropriately.

It should be cautioned that these principles, though couched in terminology found in public examinations, do NOT necessarily reflect the ways in which mathematics papers are marked in public examinations, in particular the Cambridge O Level examination.

Heads of Mathematics Department are advised to discuss these principles with their teachers and subsequently to make necessary amendments to suit the abilities of their pupils and the objectives of the school mathematics programmes. The key purpose of meaningful assessment should be to find out what the students have learnt and not what they have not yet mastered. Stressing success provides motivation for further learning.

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DRAFTING THE MARKING SCHEME

GENERAL CONSIDERATIONS

1. A marking scheme should be easy to use and yet fair to all students by allowing for special cases, especially alternative methods.

2. The scheme may need amendment as a result of changes made by moderators and when marking is actually in progress.

3. The scheme should be prepared with the question. This ensures that
   * there is an answer,
   * time taken and work done is appropriate to the marks, (allow double the time for students)
   * marks are appropriate to the difficulty level and significance of the abilities tested.

4. Fractional marks especially half marks are frequently given when
   (a) the mark is subdivided equally for several answers,
   (b) there is a small slip in the answer such as missing unit.

   This practice should be <u>avoided</u> as it makes scoring more difficult and is likely to lead to errors in addition.

5. Bonus marks should be avoided as they are likely to be given on a subjective basis. To encourage students who give excellent solutions, write positive comments instead of give bonus marks.

6. Marks are normally not awarded for neatness (except for graph, curve plotting), spelling, correct English.

7. Persistent wrong use of mathematics symbols should be penalised. E.g.: $\cos \theta = 0.5 = 60^\circ$.

However, use of symbols like $\subset \Rightarrow \Leftrightarrow$ is not necessary.

Minor details such as $x = 30^\circ$ or $x = 30$ can be ignored.

One approach is to deduct 1 mark, only once per question.

8. Marks are partitioned so that there is minimal possible scope for subjective judgment. For example, if the scheme indicates 3 marks for a method, it means the student gets either 0 or 3 marks but not 1 or 2 marks.

9. Negative marks should not be given.

10. There is no need for the total mark for a paper to be 100. Hence, there is not necessary to award 'bonus marks' for the paper as a whole to bring the total up to 100. The total mark should fit the overall structure of the paper.

11. A convenient total mark for a structured question is 12 as it is divisible by 2, 3, 4 or 6.

12. Mark all the questions and select the better ones for the required number of questions to be totalled. Put EX (tra) against the extra questions.

This practice may be changed if the school intends to train students to obey instructions strictly.

13. Work crossed out by the student should not be marked.

14. If different methods leading to different answers (may be right or wrong) are given to a problem, mark them all wrong. Giving different solutions suggests that the student is not sure of the correct method. Students are expected to cross out the unwanted ones.

However, if different methods lead to the same answer (may be right or wrong), mark all of them and choose the best (or the worst) one.

15. Advise students not to cramp too much writings on the same sheet of paper. This is helpful to the markers.

CALCULATIONS

1. Give solution in full. Check that calculations and figures are not too complex, especially algebraic manipulations.

2. Full marks are given to a correct result from any correct method, unless a particular method is specified.

   Alternative methods not envisaged in the marking scheme should be marked carefully with equivalent submarks for equivalent stages. If necessary, discuss the matter with other markers.

3. Use the following symbols:

M	Method mark
A	Accuracy mark, dependent on the M marks
B	Accuracy mark, independent on the M marks
CAO	Correct Answer Only
SC	Special cases
MR	Misread of values

4. The relative weightage given to method and accuracy varies according to the level and objectives of the examination.

   In general, method will be rated more highly than accuracy.

5. Method marks are given to correct working up to the stages (usually the key ones) indicated.

   In a multi-step working, the M marks are usually dependent on previous M marks.

   However, subsequent method errors are not used to penalise correct method at earlier stages. This approach emphases the key stages in the solution.

6. In general, M marks are not given for stating a formula or making statements such as:

   "Using the sine rule, ..."

   "Substituting x = ..."

   Mark the attempt of applying the intended procedure. The M mark is given for substituting the correct numbers in the correct formula for the problem.

   Note: At an early stage of learning, ability to recall the correct formula may be a necessary skill to be rewarded. In this case, some marks may be given for stating the correct formula.

7. Minor arithmetic errors are usually allowed in M marks.

8. Although students are asked to show all workings, certain answers may be obtained without showing much computations, especially when calculator is used. Under this circumstance, an element of doubt arises and it is common to give full credit to correct answer without working. This kind of mark is indicated in the scheme as B mark.

9. Use the symbol (✓) to indicate follow through of a correct method after a previous error. Use (✗) to indicate a further error is made, at which stage, marks are usually lost.

Errors carried forward should only be penalised once, i.e., at the stage where it first occurs. If the student has gone on to use the correct method in later stages and has correctly applied his initial wrong values, he should be given full marks for the later stages. This entails checking students' wrong numbers into the correct method and it can be indicated by the symbol f.t. (follow through). This can be time consuming. An alternative is to award full M mark but to penalise A mark.

10. Sketches drawn by students as part of solution should be examined. Sometimes, students perform intermediate steps and write values on the sketches rather than in the working. If marks are given to these sketches, decisions have to be made if students do not show sketches and yet get correct solution. The marking scheme should reflect this to avoid complete freedom for the marker to award part-marks.

11. A marks are given for correct answers, usually numerical. This is awarded only when all the relevant M marks have been obtained.

12. Sometime, answers must be given in specific form. E.g.:
probability as a fraction (not a ratio),
algebraic expression in its simplified form,
standard ways of stating bearing,
coordinates as an ordered pair (not a column vector).
In such cases, the notation CAO (Correct Answer Only) is used.

13. For many calculations, a range of values is given to reflect the degree of accuracy expected, usually 3 S.F. (using calculator, different level of approximation etc). The range should not encourage approximation at too early a stage.

It is pointless to penalise rounding off errors repeatedly. Other skills should be rewarded according to the objectives of the test.

14. If units are important, marks awarded for correctness of units must be stated, usually in the A or B marks.

Answers without units are assumed to use whatever units are mentioned in the problem.

In general, conversion to equivalent units should not be penalised, but this is time consuming.

Correct answers but wrong units are penalised.

15 Quite often an answer has several elements, such as roots of equation, elements of a set, elements of a matrix, and coordinates of points. It is not feasible to divide the A mark equally for each element as this will lead to fractional marks.

An approach is to give 1 mark for getting one or several elements correct and the rest of the mark for complete answer.

16. Misreading of values (indicate by MR) occurs frequently. If the student has misread some values and if these values do not change the nature or difficulty of the problem, give full M marks but A marks may be lost, usually between 1 to 3 marks.

However, if the misreading makes the problem too easy for the intended objectives, all the marks are lost.

GRAPHS

1. Graph work must be done on graph paper. This is a pre - requisite for marking.

2. Marks are given for the following points:

   * use given scale or choose suitable scale
   * plot correctly the stated number of points within the graph region
   * straight lines must be drawn with straight edge, not free hand
   * for curve, join all the points to give a smooth curve (clear, no shading, zig-zag, correct shape, etc)

   Suppose 2 marks are given for plotting 6 points. It is appropriate to give 1 mark for any 3 correct points and 1 more mark for the additonal 3 points.

   Quality of the line or curve is usually given 2 marks.

3. When reading off values from a graph, give a range of expected answers, usually to within one small square.

   M mark can be given to evidence of reading from graph.

   A mark can be split: 1 mark for a wider range of accuracy and more mark for closer range.

4. No mark if graphical question is done by calculation. However, using calculation to check graphical values is ignored.

Marks are given for the following points:

* use given scale
* accuracy in construction (use tracing paper or thermal transparency to check)
* labelling (if required by the question) esp for vectors
* construction lines (if necessary; advise students not to erase)
* clarity of presentation

ACTUAL MARKING

1. Indicate clearly the way in which the marks have been given. This is important for checking.

   * Use a different colour (red) from that used by the student.

   * Put a tick and write the sub-mark at the appropriate stage.

   * Put a (✓) to indicate correct method following a previous error.

   * Circle the errors and indicate omissions where marks are lost. Errors need not be corrected.

   * Lightly cross out irrelevant work.

   * Every page containing work must be marked.

   * Total the sub-marks for each question and ring the total.

   * When more than the required number of questions are given, discount the worst one(s).

   * Total the marks for a script at the end. Check the total by adding the sub-marks and the ringed marks separately: they should tally.

2. Update marking scheme to take account of alternative acceptable methods and answers. Sometimes, part marks may need to be adjusted.

3. To improve consistency, it is better to mark all scripts to each question together before going on to the other questions. It helps to eliminate the 'halo effect': the tendency to be unduly affected by a good (or poor) answer to the early part of the paper and to mark the remainder more sympathetically (or harshly).

COORDINATING THE MARKING

Inconsistency can arise from: the same marker marking at different times, differences among markers.

When two or more teachers mark the same paper, it is necessary to ensure that they all mark to the same standard. Coordination may be undertaken by HOD or appointed chief marker.

Elaborate coordination may follow the following procedures:

1. Chief marker provides each marker with a copy of the marking scheme.

2. Chief marker distributes photocopied scripts to the markers who will mark them according to the scheme. Each marker keeps a brief record of answers not envisaged in the scheme.

3. After marking, the markers discuss any discrepancies among them and make any amendments to the scheme. A discrepancy of about 2% cannot be avoided.

   It is important that markers interpret the scheme correctly.

4. The markers then proceed to mark the scripts allocated to them.

5. When marking is in process, the chief marker inspects the marking of a sample of scripts ($\simeq$ 10 %) from each marker, looking particularly at scripts near to the pass/fail and credit/distinction borderlines. The chief marker will discuss with the markers any discrepancies in their markings. The chief marker should also check the totalling of marks of the inspected scripts.

6. When all the scripts have been marked and checked, examine the means and standard deviations of each marker. Differences may be due to difference in marking standard or different level of performance of students. If the groups are known to be different, it may not be necessary to make further adjustment.

7. As a rough guide, for number of students below 50, differences between means of 5% or more and differences between standard deviations of 3% or more may be investigated. This may involve random re-marking of scripts (especially borderline cases, half standard deviation about the pass mark) by the chief marker and the markers. The purpose is to provide further opportunity to put right any discrepancies which may have occurred.